CHARACTERIZATION OF PHYSICAL PROPERTIES KUANTAN BAUXITE

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ABSTRAK

Di Kuantan terdapat mineral asli dan geokimia bauksit yang telah terbentuk, namun kurang pengetahuan dan pengalaman dalam mengendalikan bauksit telah menyebabkan pencemaran udara dan air di sekitar kawasan tersebut. Aktiviti di kawasan bauksit telah diharamkan oleh kerajaan atas dasar keselamatan dan kesihatan penduduk setempat sebelum ini. Kini kerajaan telah memutuskan untuk membina kawasan pembangunan baru di tanah bauksit tersebut. Bauksit adalah batu yang mengandungi banyak komposisi dan berlaku dalam banyak struktur yang berbeza. Satu kajian telah dibuat untuk mengetahui sifat-sifat fizikal bauksit di sesetengah kawasan di dalam daerah Kuantan dan kajian ini adalah untuk penyelidikan di masa hadapan mengenai bauksit di Kuantan. Ujian makmal telah dilakukan di tiga kawasan yang berbeza iaitu Semambu, Bukit Goh dan Indera Mahkota. Sifat-sifat fizikal bauksit di daerah Kuantan tersebut akan dikenalpasti melalui ujian kandungan kelembapan tanah, particle size distribution, atterberg limit dan specific gravity. Dengan merujuk jurnal dari penyelidik pada tahun sebelumnya, thesis ini telah mencapai objektif.

ABSTRACT

In Kuantan there was an origin mineral and geochemistry of Bauxite had been formed, however less knowledge and experience in handling the Bauxite had cause air and water pollution around the Bauxite area. The Bauxite area has been banned once but the government of Kuantan had decided to construct a new development area on the Bauxite soil. This study, as it can be specify the bauxite is a rock that contain a lot of composition and it takes place in different texture in form. An investigation of engineering characterization and physical properties of the bauxite had been carry out at different site in Kuantan for future research about Kuantan bauxite. Laboratory test had been done at three different sites where the sites is at Semambu, Bukit Goh and Indera Mahkota. This investigation is to identify the physical properties of the bauxite at Kuantan sites by do the lab test of moisture content, particle size distribution, atterberg limit and specific gravity. The result had been compared and refers from the other researchers and journal to prove whether this research had achieve the objective or not. Referring to the other researchers and journals, this research objective had been achieved and prove that the result of bauxite sample that had been taken for laboratory testing was in the range of bauxite soil.

TABLE OF CONTENT

DECLARATION

TITLE PAGE

ACKNOWLEDGEMENTS **ii**

ABSTRAK **iii**

ABSTRACT **iv**

TABLE OF CONTENT **v**

LIST OF TABLES **viii**

LIST OF FIGURES **ix**

LIST OF ABBREVIATIONS **x**

CHAPTER 1 INTRODUCTION **1**

1.1 Background of Research 1

1.2 Problem Statement 2

1.3 Objective of Study 3

1.4 Scope of Study 3

1.5 Significant of Study 4

CHAPTER 2 LITERATURE REVIEW **5**

2.1 Introduction 5

2.1.1 Definition 5

2.2 Bauxite Geotechnical Properties 6

2.3 Formation Process of Bauxite 7

2.4 Physical Properties of Soil 8

2.4.1 Moisture Content 8

2.4.2 Particle Size Distribution 9

2.4.3 Atterberg Limit 10

2.4.4 Specific Gravity 11

2.5 Research Gap 12

CHAPTER 3 METHODOLOGY 13

3.1 Introduction 13

3.2 Research Methodology Flowchart 13

3.3 Sample Collection 15

3.3.1 Bauxite Soil Sample 15

3.4 Preparation of Sample 16

3.5 Moisture Content Test 17

3.6 Sieve Analysis Test (Particle Size Distribution) 18

3.7 Atterberg Limit 21

3.7.1 Test Procedure Liquid Limit 21

3.7.2 Test Procedure Plastic Limit 23

3.8 Particle Density Test 24

CHAPTER 4 RESULTS AND DISCUSSION 27

4.1 Moisture Content 27

4.2 Particle Size Distribution 27

4.3 Atterberg Limit 29

4.4 Specific Gravity 29

CHAPTER 5 CONCLUSION 30

5.1 Conclusion 30

5.2 Recommendation 30

REFERENCES **32**

APPENDIX A SAMPLE APPENDIX 1 **34**

APPENDIX B SAMPLE APPENDIX 2 **36**

APPENDIX C SAMPLE APPENDIX 2 **38**

APPENDIX D SAMPLE APPENDIX 1 **42**

LIST OF TABLES

Table 2.1 Particle size analysis 10

Table 2.2 Summary of previous study 12

Table 4.1 Average atterberg limit test result at different sites 29

LIST OF FIGURES

Figure 1.1 Bauxite sample location 3
Figure 2.1 Bauxite rock 6
Figure 2.2 Atterberg limit graph 10
Figure 2.3 Average of specific gravity at Gebeng 11
Figure 3.1 Flow chart of methodology 14
Figure 3.2 Location of sample at Semambu,Kuantan site 15
Figure 3.3 Undisturbed sample collection 16
Figure 3.4 Disturbed sample collection 16
Figure 3.5 Sample of soil (Dry Soil) 17
Figure 3.6 Cooling dry soil 17
Figure 3.7 Weighting dry soil 18
Figure 3.8 Good condition of sieve 19
Figure 3.9 Weighing each sieve 19
Figure 3.10 Arrangement of sieve by sieve size 20
Figure 3.11 Sieve in the mechanical sieve shaker 20
Figure 3.12 Mixed soil 21
Figure 3.13 Smooth surface by straight edge 22
Figure 3.14 Cone penetration 23
Figure 3.15 Clean pycknometer density bottle 24
Figure 3.16 Pycnometer density bottle in the vacuum dessicator 25
Figure 3.17 Clean pycnometer density bottle with full of water 26
Figure 4.1 Graph of average moisture content at different site 27
Figure 4.2 Percent fine versus particle size at Semambu 28
Figure 4.3 Percent fine versus particle size at Bukit Goh 28
Figure 4.4 Percent fine versus particle size at Bukit Goh 28
Figure 4.5 Average specific gravity at different site 29

LIST OF ABBREVIATIONS

PLAN	Federal Department of Town and Country Planning
ASTM	American Society of Testing and Material
IMSBC	International Maritime Solid Bulk Cargoes

CHAPTER 1

INTRODUCTION

1.1 Background of Research

Residual rock called 'Bauxite' were formed from the weathering of various igneous, sedimentary, and metamorphic rocks. These rocks have been exposed to long periods (millions of years) of weathering under tropical, subtropical, or very wet temperate conditions. Ninety percent of bauxite resources in the world are mostly in tropical area. Other deposits outside these latitudes have been exposed to long periods of intense weathering in their geologic past(Hasan et al, 2018). The most common country that consist a large amount of bauxite are in Central and South America, in West Africa, in particular Guinea, and then in India, Vietnam, and Australia. Some of the bauxite also available in the north of Russia and in the centre of Saudi Arabia. The bauxite resource had been estimated and it was more than 70 billion tonnes of bauxite in the world. Of this the greatest concentration is in Guinea, where there are well-proven resources of approximately 25 billion tonnes (Description & Risks, 2014). Most of the bauxite was occurred close to the surface, with only 1 or 2 m of overburden and typical range of the thickness is between 3 to 15 m.

Bauxite is a type of rock that majority of it contain ore alumina and it had been recognized at the end of the nineteenth century that the rock is also contain other composition which include Gibbsite (aluminium hydroxide, Al (OH)3), Boehmite, Diaspore, A10 (OH), goethite and haematite, kaolinite (aluminium silicate, Al2Si2O5(OH)4) and a small quantity of anatase (titanium oxide, TiO2)(Plunkert, 2003).This rock called bauxite normally have a typical soft texture (Mohr's Hardness: 1-3) and it has a low specific gravity (Gs: 2.0-2.5). The colour of the bauxite is white to grey to reddish brown and sometimes stained yellow or brown by iron of combination colours, but the majority colour of bauxite is reddish brown and it is because of the presence of iron mineral in it.

This study is to investigate whether the bauxite is suitable or strong enough to hold an engineering structure for a long term period. The strong and stable soil is important when it is comes to a building especially the foundation part. Different type of soil has their own characteristic of strength and physical properties. The lower the strength, the less stability the stability of the soil that can cause cracking, sinking and settlement effect. Certain skyscraper and tower had been supported by the soil because of a high strength of soil. This is became texture of soil consist relative proportions of various particle sizes such as sand, silt and clay. In this study, as it can be specify the bauxite is a rock that contain a lot of composition and it takes place in different texture in form. So this study is an investigation of engineering characterization and physical properties of the bauxite that will be carry out at different site in Kuantan.

1.2 Problem Statement

Bauxite in Kuantan had become an environmental issue in Malaysia due to the pollution of air, redness of water. Gebeng and Bukit Goh are the main source of Aluminium ore in Kuantan that had been ban by the government. From that particular problem, Kuantan municipal council and Federal Department of Town and Country Planning (PLAN) Malaysia are on a planning of Kuantan 2035. There will be more development of construction and land use in this urban area. This study is to know whether the bauxite soil is suitable or not to be used as a residential area.

Therefore, a case study need to be done to provide more information about the bauxite soil engineering and physical properties of the bauxite in Kuantan. This study is to obtain information whether the bauxite in Kuantan is safe to be used for developed a building area and to be confirm by the Geotechnical design.

1.3 Objective of Study

This research is to investigate and identify the geotechnical properties of raw and processed bauxite in Kuantan area. The sample that will be test are from Gebeng and Bukit Goh bauxite area. Then, it can be conclude whether the bauxite could be used as a housing area or not.

i. To determine the physical properties of the bauxite in Kuantan.
ii. To compare the sample of bauxite at different site in Kuantan.
iii. To analyse the physical properties by graph and data that will be obtain.

1.4 Scope of Study

This research is carry out by a full laboratory test to explore more about the properties of Kuantan bauxite. The sample of Bauxite ore were taken from Gebeng and Bukit Goh which are located 39km and 23km from Kuantan. Three samples had been taken at both location at difference spots.

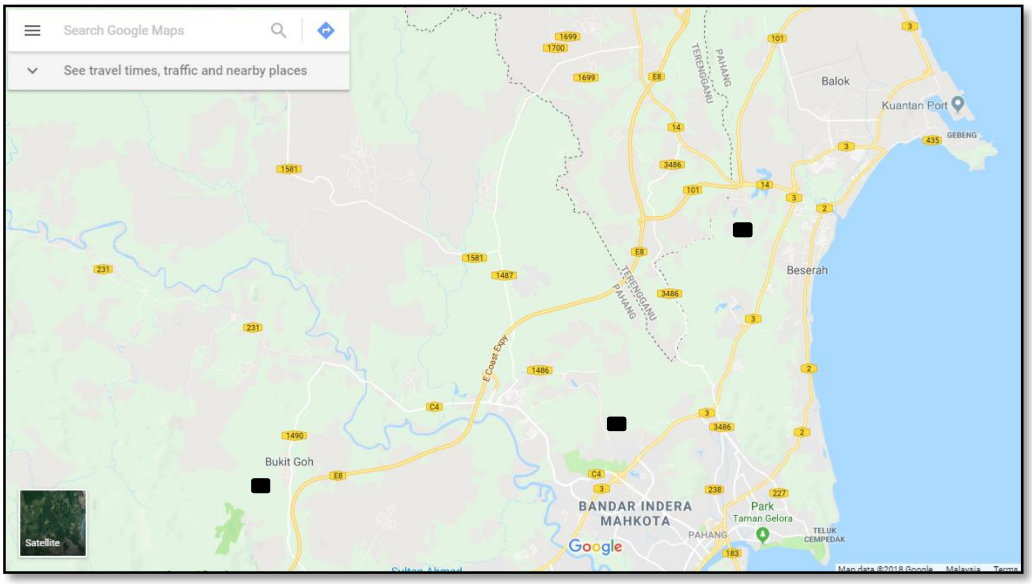

Figure 1.1 Bauxite sample location

The bauxite sample been test according to the American Society of Testing and Material (ASTM) D 1889 – 73 and British Standard 1377 (BS1377). The sample physical properties was determined by tests below:

i. Moisture Content Test

ii. Particle Size Distribution (Sieve Analysis Test)

iii. Atterberg Limit Test

iv. Specific Gravity

1.5 Significant of Study

The importance of this study is to analyze the physical properties of bauxite in Kuantan area at different site. The result of this study the proper guideline to handle whether the area of the bauxite can be used for a housing area or not. The physical properties of bauxite is consist of structure and texture, porosity and the moisture content and organic matter is influence by the mineral in aluminium ore. Buildings crack when not placed on soil with proper qualities. To determine the bauxite is safe and have good physical quantities to be used as a housing area of soil, experiment and investigation had been used to know the result of this type of soil structure.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter of literature review is to gain more knowledge that related to the bauxite physical properties and engineering characterization of the bauxite in Kuantan area.

2.1.1 Definition

Bauxite is a result of intense leaching in a hot and humid climate with alternating wet and dry seasons and good downward drainage. The climate promotes vegetation that provides organic acids, which help to dissolve rocks in percolating water that carries more soluble components away, leaving only aluminum and also often iron as the least mobile common ions behind. This process is known as lateritization. Hence, bauxite is an aluminum-rich laterite. The accumulation of aluminum-rich residuum, as opposed to one enriched in iron, is a function of higher rainfall, but also lower average temperature (around 22 °C rather than 28 °C). Aluminum in bauxite is hosted by aluminum hydroxide minerals, mostly gibbsite. The major impurities are iron oxides and hydroxides (which give reddish color to most bauxites) and clay minerals. Bauxite is a weathering product of aluminum-bearing rocks (usually igneous rocks).

Figure 2.1 Bauxite rock

The physical characteristics of bauxites depend upon the source material, whether they are derived from khondalite, shale or metavolcamcs. The bauxite ore is very hard and massive at the top and moderately spongy below. The light buff to creamy white coloured bauxite indicates high grade and is observed mostly on the surface and bauxite with pale pink colour and clayey appearance, have been found to appear towards the lower part of the bauxite zone. Hard ferruginous bauxite ore is encountered m bauxite as pockets, which has very low extractable alumina The soft lateritic bauxite, spongy soft and limonitic bauxite retaining lineation of original sillimanites in parent rock give higher percentage of extractable alumina (Hao et al., 2010).

2.2 Bauxite Geotechnical Properties

There are two main categories of bauxite which are lateritic bauxite and karst bauxite. Karst bauxites that overly carbonate rocks regardless of the degree of karstification and lateritic bauxites that overly alum silicate rocks. Karst type deposits originate from a variety of different materials, depending on the source area. Lateritic bauxite is generally formed by in-situ lateritization, therefore, the most important factors in determining the extent and grade of it are thought to be the parent rock composition, climate, topography, drainage, groundwater chemistry and movement, location of the water table, microbial activity, and the duration of weathering processes (Gu et al., 2013). In addition, lateritic bauxites can be directly related to the underlying source rocks through their textures and compositions.

2.3 Formation Process of Bauxite

The processes involved transformation of soil in bauxite are more complex than shown below, but the following example for weathering of feldspar is indicative of the overall net formation sequence.

Step 1: Acidification of rainwater

$$CO_2 + H_2O \rightarrow H_2CO_3 \qquad 2.3.1$$

$$H_2CO_3 \rightarrow HCO_{3-} + H_+ \qquad 2.3.2$$

$$HCO_{3-} \rightarrow CO_{32-} + H_+ \qquad 2.3.3$$

Step 2: Carbonic and humic acids (from soil) react with feldspar, leaching potassium and silica, and hydrating the alumino-silicate structure to form an illite clay:

$$3KAlSi_3O_8 + 2H_+ + 12H_2 \rightarrow KAl_3Si_3O_{10}(OH)_2 + 2K + 6Si(OH)_4 \qquad 2.3.4$$

Step 3: Further leaching removes the remaining potassium, transforming illite to kaolinite:

$$2KAlSi_3O_{10}(OH)_2 + 2H_+ + 3H_2O \rightarrow 3Al_2Si_2O_5(OH)_4 + 2K_+ \qquad 2.3.5$$

Step 4: Kaolinite is decomposed to form insoluble gibbsite and soluble hydrated silica:

$$Al_2Si_2O_5(OH)_4 + 5H_2O \rightarrow 2Al(OH)_3 + 2Si(OH)_4 \qquad 2.3.6$$

Iron in the minerals is converted to the insoluble forms hematite and goethite. Titanium is transformed to anatase. Quartz and zircon are resistant to weathering.

The mixture of remnant minerals is called ‘laterite’ and is a common surface feature in tropical areas. If it is sufficiently high in alumina and low in silica, it is characterised as ‘bauxite’. Laterite bauxites account for most of the world’s major deposits of bauxite.

Weathering of limestone gives rise to eroded surface and sub-surface features (caves & depressions) which are together known as ‘karst’. If the voids are subsequently filled with minerals containing aluminium, then further weathering may occur leading to bauxitisation. The resulting deposits are known as karst bauxite. They are important in Europe, China and Jamaica (Gu et al., 2013)

2.4 Physical Properties of Soil

2.4.1 Moisture Content

The moisture content of soil also referred as water content is an index of the amount of water present in soil. By definition, moisture content is the ratio of the mass of water in a sample to the mass of solids in the sample and express as a percentage. The porosity of soil effect the moisture content and the moisture content increase when the porosity of soil increase. The percentage of water content will be determined by using those equation:

Determine the mass of moisture soil, Ms.

$$M_S = M_{SL} - M_{DL} \qquad 2.4.1$$

Determine the mass of dry soil, M_D.

$$M_D = M_{SL} - M_L \qquad 2.4.2$$

Determine the mass of water content.

$$w\ (\%) = \frac{M_D}{M_S} \times 100 \qquad 2.4.3$$

2.4.2 Particle Size Distribution

A study of the particle size distribution of the bauxite physical properties will be carry out by sieve analysis test. This test is to determine the range size of the soil sample for this research based on the retained soil mass for each sieve size. The result that obtain from this test will conduct a curve where we can state the characteristic of the soil. From the particle size distribution curve, three point of characteristic size will be taken for uniformity coefficient, Cu and coefficient of gradation, Cc. The formula for uniformity coefficient, Cu and coefficient of gradation, Cc are as follows:

$$Uniform\ Coefficient, Cu = \frac{d_{60}}{d_{10}} \qquad 2.5.1$$

$$Uniform\ Coefficient, Cc = \frac{(d_{30})^2}{d_{10} \times d_{60}} \qquad 2.5.2$$

Based on the typical grain size distribution curve, it consist of different particle sizes which are known as D10, D30 and D60. D10 is for 10% of finer particles, D30 for 30% of finer particles and D60 is soil particle for which 60% of fine particles where can find the value of uniformity coefficient, Cu and coefficient of gradation, Cc.

Based on the previous research, three sample of bauxite had been analyse and the percentage of particle distribution for passing the sieve size of 2.5 mm have a high value. Refer to IMSBC, the range of percentage of passing sieve 2.5 for cargo transportation is between 10 to 30 percent. Table 2.1 shows that the bauxite have a high percentage of fine size particle and this situation will increase the risk of liquefaction to occur during transportation of bauxite in bulk cargoes (Hasan et al, 2017).

Table 2.1 Particle size analysis

	Particle size (%)	
Sample	< 2.5mm	> 2.5 mm
GBIS1	41	59
GBIS2	34	66
GBIS3	41	59

2.4.3 Atterberg Limit

Atterberg is divided the entire range of soil state (from liquid to solid state) into four stages, which is known as Atterberg Limits that consist of plastic limit, liquid limit, semi-solid state and solid state as figure 2.2. Based on this research, this atterberg limit test is to collect data for the plastic limit and liquid limit stage.

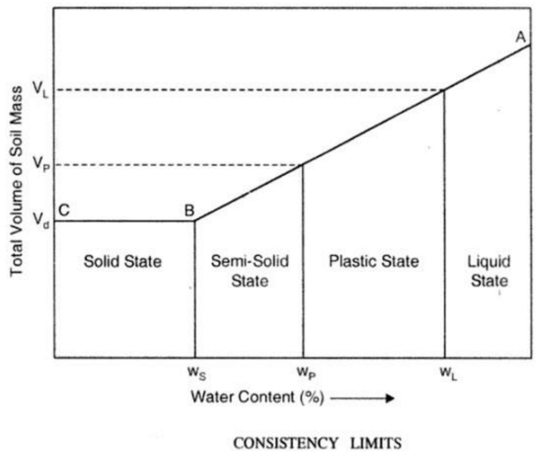

Figure 2.2 Atterberg limit graph

Sundaram and Gupta (1986) have some in-situ investigations on bauxite soil for usage of foundation and they discover that the bauxite is high in alkaline (9.3-10.2) with liquid limit of 39-45 %, plastic limit of 27-29% and shrinkage limit of 19-22%. They also found that undrained shear strength is 0.4 to 1.4 kg/cm2, specific gravity is 2.85-2.97, cohesion is 0.1 to 0.2 kg/cm2 and angle of internal friction is 26-280.

Vick (1981) observed that red mud is of low plasticity with liquid limit (LL) of 45% and plasticity index (PI) of 10% with relatively high specific gravity (GS) of 2.8-3.3. This show that this soil geotechnical properties is similar to clayey tailing such as mineral, sands and gold due to its lack of clay mineralogy.

2.4.4 Specific Gravity

Specific gravity is the ratio of the mass unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature. The specific gravity of soil is used in the phrase relationship of air, water and solids in a given volume of the soil. The specific gravity was determine by using small pycnometer method.

Sample	Specific Gravity of Container 1	Specific Gravity of Container 2	Average Specific Gravity
GBIS1	2.77	2.74	2.75
GBIS2	2.75	2.76	2.75
GBIS3	2.88	2.85	2.87
GBSP1	2.88	2.89	2.88

Figure 2.3 Average of specific gravity at Gebeng

The average specific gravity at Gebeng that had been shown above prove that the specific gravity of bauxite is in the range of 2.5 – 3.0 (Muzamir Hasan, 2017). Result of above samples was obtained by using the pycnometer method where the method used for this research. The result for this research can be refer from the journal of basic properties of Gebeng by Muzamir (2017).

2.5 Research Gap

From the literature review, it can be conclude that the researchers mostly analyse physical properties of the bauxite residue based on the shear strength, limit state of soil and some of the result could not be compare because of less information. However, the result for proctor test and density had less information of journal and article. Based on the result that had been obtained by the researchers can be compare and refer for this research and observation of bauxite in Kuantan. For physical properties test, there is quite less information from the previous researchers.

Table 2.2 show the gap of study of the previous research about the physical properties of bauxite residue. This research is to obtain the physical properties information based on certain test that will obtain the result of physical properties of bauxite in Kuantan.

Table 2.2 Summary of previous study

Author	Year	Title	Remarks/Finding
Deelwal,Kusum Dharavath, Kishan Kulshreshtha, Mukul	2014	Evaluation Of Characteristic Properties Of Red Mud For Possible Use As A Geotechnical Material In Civil Construction.	This journal is consist of maximum dry density and optimum moisture content of the bauxite test result.
Hasan, Muzamir Aziz, Siti Hajar Nursyafiqah, Wan Jusoh, Wan	2017	Basic Properties of Gebeng Bauxite in Accordance to IMSBC Code.	This research is to analyse the particle distribution of bauxite based on IMSBC code
Sundaram, Ravi Gupta, Sanjay Mud, R E D	1986	Constructing Foundations on Red Mud.	The researcher do an in-situ investigations on engineering physical properties of bauxite soil for usage of foundation.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this investigation, a sample of bauxite had been taken to know some result of the physical properties .There are certain test that I did to have a result of the characterization of physical properties Kuantan bauxite by moisture content test, sieve analysis, atterberg limit, specific gravity test and compaction test.

In order to figure out the physical properties of bauxite, the test that had been stated above is to determine the percentage of moisture content, to obtain basic index information about the soil used to estimate strength and settlement characteristic as plasticity index, plastic limit, liquid limit and shrinkage limit, to obtain the particle size distribution and grading curve for the bauxite soil sample and the specific gravity of bauxite. In this study, the experiment that were carried out through study were discussed and this chapter explain the material use and also brief on the testing method.

3.2 Research Methodology Flowchart

Figure 3.1 explain the flow for this research of characterization physical properties of bauxite in Kuantan.

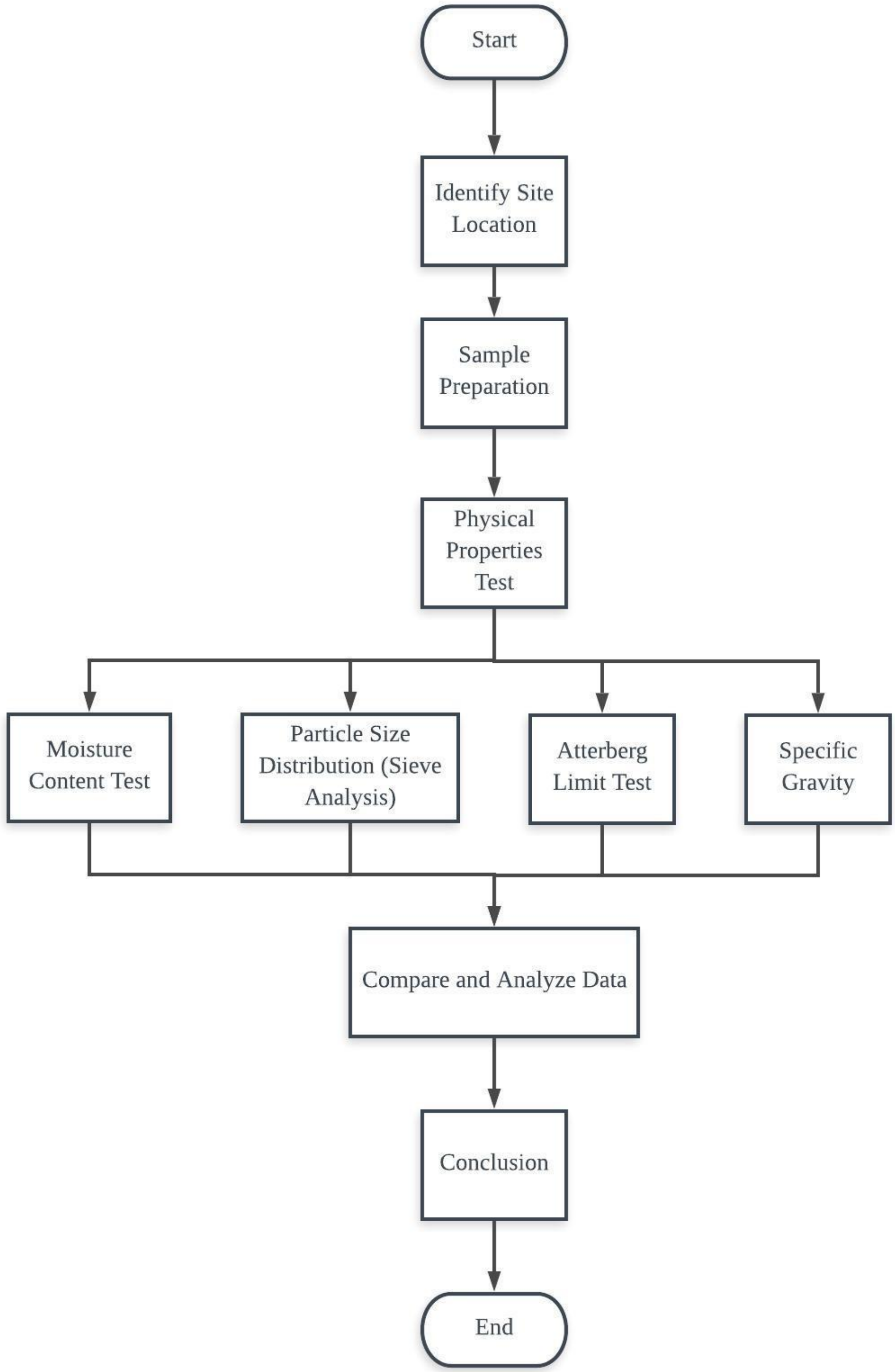

Figure 3.1 Flow chart of methodology

3.3 Sample Collection

In this research of characterization of bauxite physical properties, the material that we need to do the lab testing is bauxite soil sample. This soil sample had been collected from Semambu, Kuantan site (Figure 3.2).

Figure 3.2 Location of sample at Semambu,Kuantan site

3.3.1 Bauxite Soil Sample

This bauxite soil sample had been taken a day before we start to do the soil testing. We went to Semambu to collect the sample by using the hollow pipe to get the undisturbed soil and disturb soil. This sample was collected by using hand auger for undisturbed soil as in Figure 3.3 and Figure 3.4 for disturbed soil.

Figure 3.3 Undisturbed sample collection

Figure 3.4 Disturbed sample collection

3.4 Preparation of Sample

In this investigation, the sample should be dry first before start a testing because this sample will be sieve accept for moisture content test. The soil will be dry in the oven of temperature 105°C for a day or until it dry. After the dry section, then we can start to do a soil testing for the bauxite soil (Figure 3.5).

Figure 3.5 Sample of soil (Dry Soil)

3.5 Moisture Content Test

Based on the sample that had been collected, it had been test to know the moisture content of the soil. The test had been conducted by the procedure below.

i. Mass of the empty metal canister had been recorded.

ii. Then, placed the moist soil in the metal canister. Mass of the metal canister which contain the moist soil had been recorded.

iii. After mass the metal canister that contain moist soil, had been placed into the drying oven where the temperature is between 105^{o}C to 110^{o}C and left it overnight.

Figure 3.6 Cooling dry soil

iv. After overnight the soil, the metal canister that contain dry soil as Figure 3.4.3 had been left in a room temperature area to ensure the soil is cool before weighting. The mass of metal canister which contain the cool dry soil had been recorded.

Figure 3.7 Weighting dry soil

v. Lastly, used equipment that had been clean and had arranged it back to the original place.

3.6 Sieve Analysis Test (Particle Size Distribution)

Sieve analysis test is to obtain the percentage of particle size distribution from the soil sample. Based on the sieve analysis test that had been ran, the procedure of the sieve analysis is as below:

i. First of all, mass of dry soil sample approximately 500g had been recorded.

ii. Then, check whether the sieve was in a good condition before used as Figure 3.8.

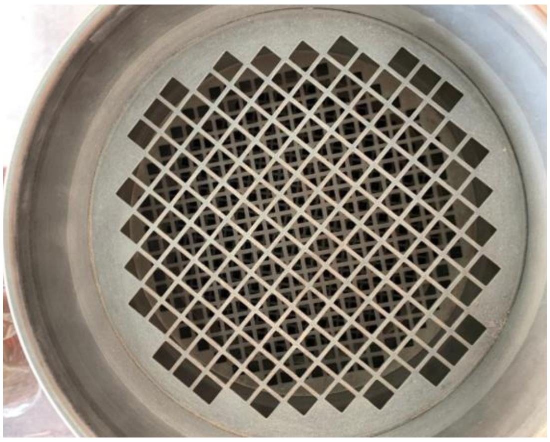

Figure 3.8 Good condition of sieve

iii. Before arrange the sieve, each sieve had been weighed first and the mass had been recorded. (Figure 3.9).

Figure 3.9 Weighing each sieve

iv. From the large size at the top and the smaller size at bottom of sieve had been arranged. Cover the top sieve by lid and the bottom sieve by pan like shown in Figure 3.10.

Figure 3.10 Arrangement of sieve by sieve size

v. At the upper sieve, the dry soil sample had been poured into it and cover it with lid.

vi. The sieve that had been arranged will be put into the mechanical sieve shaker for 10 minutes to obtain a result of each sieve as Figure 3.11.

Figure 3.11 Sieve in the mechanical sieve shaker

vii. When the timer ends, take out the sieve from the mechanical sieve shaker.

viii. The mass of the retained soil on each sieve should be obtain by weighting each sieve and subtracting it with the mass of empty sieve.

ix. Collect the data and calculate the percentage of retained and passing of soil.

3.7 Atterberg Limit

Atterberg limit test is where the result of the test is to know the plastic limit and liquid limit of the soil sample. It is based on the moisture of the soil where it defines the changing of soil from semi-solid to a plastic state.

3.7.1 Test Procedure Liquid Limit

i. An approximate 300g of dry soil sample that passed the sieve of 425µm is prepared and been put on a glass plate.

ii. The soil mixed at least for 10 minutes but sometimes, it will be up to 14 minutes if the soil is a heavy clays. Some water added to give a cone penetration of 15mm (Figure 3.12).

Figure 3.12 Mixed soil

iii. Then, the soil paste been pressed into the metal cup from the corner of the metal cup to avoid trapping air. Press more paste into the bottom cup and after that, fill at the middle and press well down without creating an air pocket. The soil paste been filled in the metal cup by a small spatula.

iv. The surface of the soil in the metal cup was smooth by using the straight edge of spatula as Figure 3.13.

Figure 3.13 Smooth surface by straight edge

v. The cone locked and the shaft near the upper end of its travel and lower the supporting assembly carefully and the cone had been gap within a few millimetres from the surface of soil.

vi. The timer had been set into 5 seconds and the button pressed. Then, wait until it finish counting and then adjust the height of the dial gauge until it touch the top of the cone shaft. The reading of the dial gauge recorded to the nearest 0.1mm as Figure 3.14.

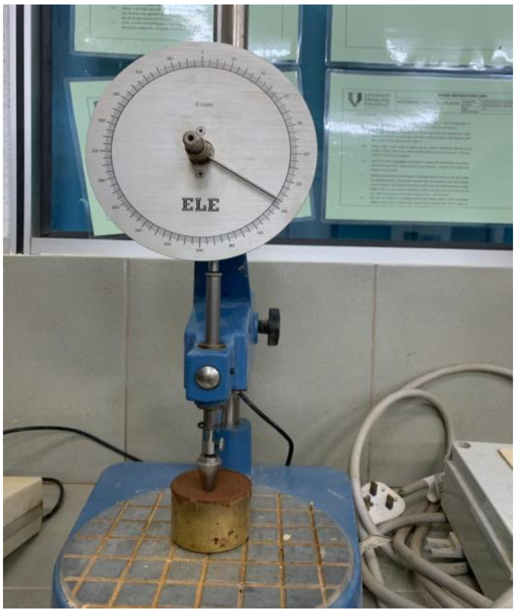

Figure 3.14 Cone penetration

vii. Lift the cone and cleaned. Avoid to touch the sliding stem and a little more wet soil been added to the cup without entrapping air. Smooth off and repeat from procedure ii.

viii. 10gm of moisture content sample been collected from the penetrated area by using the tip of the spatula and put it in metal canisters. Record the mass of metal canister that contain the moisture content sample.

ix. Then, dry the soil by placed it in the drying oven. After the sample dried, record the mass of the sample.

3.7.2 Test Procedure Plastic Limit

i. The metal canisters been weigh and recorded.

ii. The remaining ¼ of the original soil sample been took and add distilled water until it texture is smooth and can be rolled without sticking to the hand.

iii. The original soil sample rolled with constant energy and transformed it into thread that approximated 3mm diameter.

iv. When it achieve the 3mm diameter, it been folded and continue rolling until it crumble under the constant pressure. When it can no longer be rolled into 3mm of diameter thread rolling will be stopped.

v. The crumble thread putted into a metal canister and the metal canister can that contain the crumble thread soil been weigh and recorded.

vi. The metal canister can which contain the crumble thread soil into the drying oven been dried for at least 16 hours.

vii. Step iii until vi been repeated for another metal canister can.

viii. Lastly, the mass reading of metal canister can that contain dry crumble thread soil recorded.

3.8 Particle Density Test

This particle density test is obtain by using small pycnometer method and the objective of this test is to determine specific gravity of soils consisting of clay, silt and sand-sized particle. The procedure of this test as follows:

i. Dry and weight the pycnometer bottle with the stopper but make sure the bottle is clean as in figure 3.15.

Figure 3.15 Clean pycknometer density bottle

ii. The dry soil sample at temperature 105°c – 110°c had been cooled inside the desiccator.

iii. 5-10gm of sample soil that had passed through sieve 2mm been transfer into the density bottle. The weight of the bottle, content and stopper had been recorded.

iv. Then, the density bottle that contain soil been filled distilled water until it achieve half of the density bottle. The bottle without stopper been placed into the vacuum desiccator about an hour or until there is no further loss of air is apparent as figure 3.16 shows.

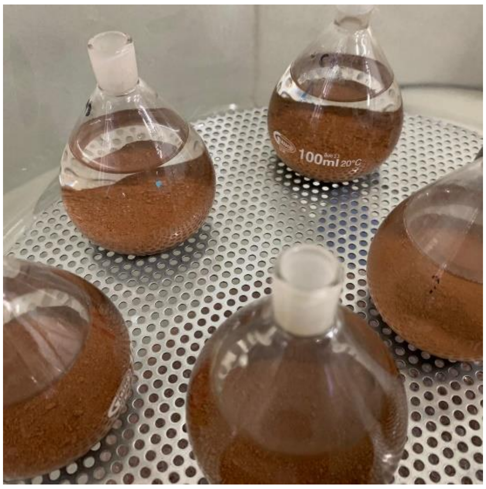

Figure 3.16 Pycnometer density bottle in the vacuum dessicator

v. After finished, shake the bottle and full the bottle with distilled water. Leave the full bottle for an hour in a room temperature.

vi. Placed the stopper and wipe the surface dry. The weight of the bottle, content and stopper had been recorded.

vii. Then, the bottle been cleaned and refill with water until full as shown in figure 3.17. Leave it for an hour.

Figure 3.17 Clean pycnometer density bottle with full of water

viii. The test had been repeated twice with the same soil sample.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Moisture Content

The results of test for moisture content for soil sample of bauxite deposit are tabulated in Appendix A. The graph of moisture content as Figure 4.1 show the result in percentage of the average at different site. Each site consist 5 points of sample that 25 meters away from each point to obtain the average moisture content. The graph show clearly that the average of moisture content at Semambu had the highest percent than Bukit Goh and Indera Mahkota site.

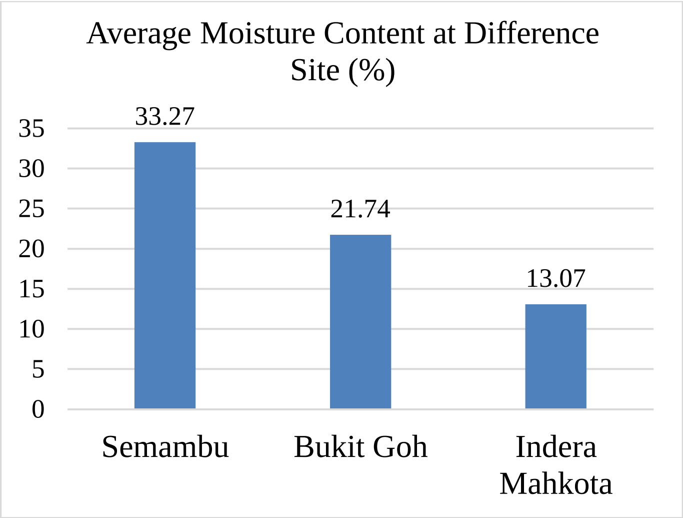

Figure 4.1 Graph of average moisture content at different site

4.2 Particle Size Distribution

Appendix B show all the tabulated laboratory result. From the result that had been obtain from the sieve analysis test, the bauxite soil explain and prove the soil is a clayey sand soil where the bauxite have more of coarse fraction passing through No.4 sieve

(4.75mm). Graph 4.2, 4.3 and 4.4 show the result of particle size distribution for Semambu, Bukit Goh and Indera Mahkota.

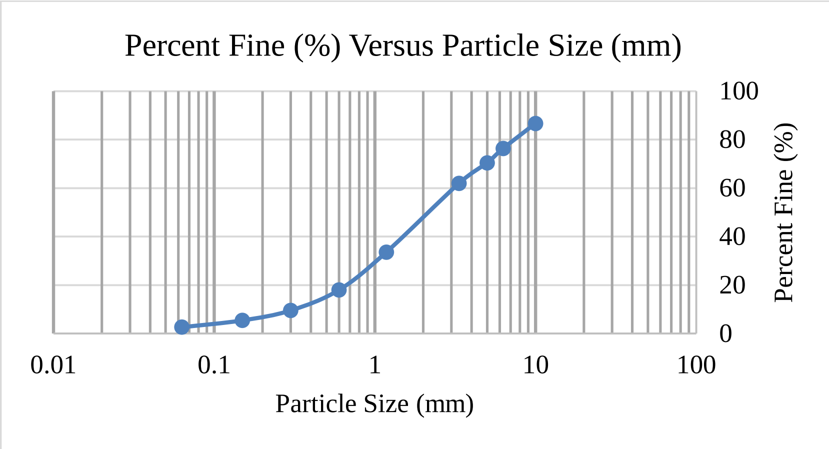

Figure 4.2 Percent fine versus particle size at Semambu

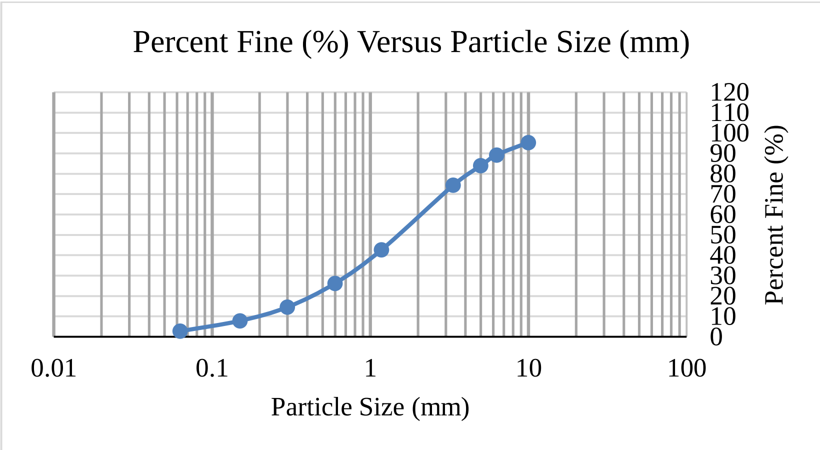

Figure 4.3 Percent fine versus particle size at Bukit Goh

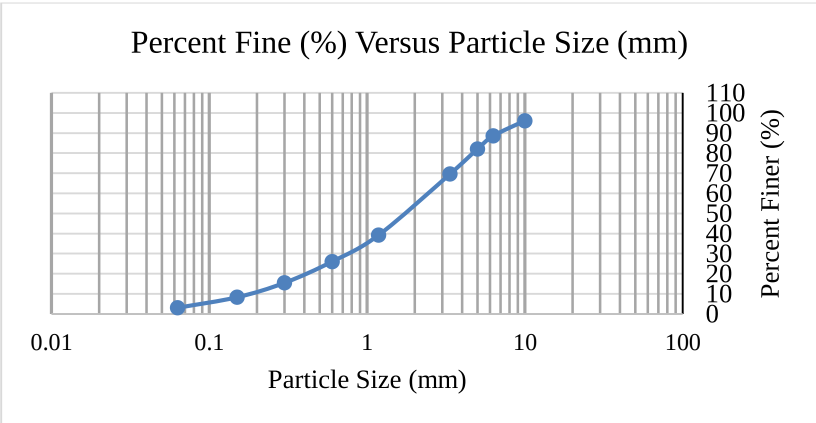

Figure 4.4 Percent fine versus particle size at Bukit Goh

4.3 Atterberg Limit

The tabulated result of test for atterberg limit was shown in Appendix C. Atterberg limit is consist of liquid limit, plastic limit and shrinkage limit. Table 4.1 show the result of liquid limit, plastic limit and shrinkage at Semambu, Bukit Goh and Indera Mahkota. Based on the table below, Semambu got the highest value of liquid limit and plastic limit and it obtain the lowest value of linear shrinkage. For plasticity index, Bukit Goh got 8.45 which is the value was higher than the other sites.

Table 4.1 Average atterberg limit test result at different sites

Site	Semambu	Bukit Goh	Indera Mahkota
Average moisture content of liquid limit (%)	54.66	46.25	31.62
Average moisture content of plastic limit (%)	46.90	37.80	25.59
Linear shrinkage (%)	7.19	7.81	8.08
Plasticity Index	7.76	8.45	6.03

4.4 Specific Gravity

The result for specific gravity at different site had been tabulated in appendix D. From the figure 4.5, it show that Bukit Goh had the highest value of specific gravity than Semambu and Indera Mahkota.

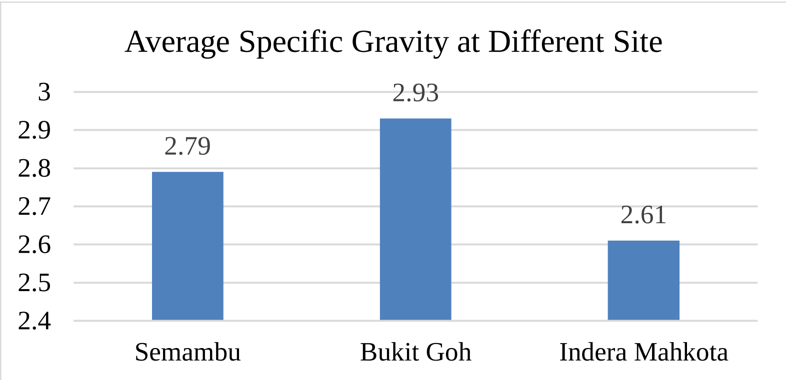

Figure 4.5 Average specific gravity at different site

CHAPTER 5

CONCLUSION

5.1 Conclusion

As a conclusion from the experiment that had been observed, the objective for this physical properties of bauxite at Kuantan research had been successfully achieves. The conclusion are as follow:

1. The journal basic properties of Gebeng bauxite prove that the moisture content of bauxite in Kuantan based on this experiment is in the range of bauxite percentage.

2. The result for particle size distribution and atterberg limit show that the bauxite is in the group of clayey sand where had been prove by using the Unified Soil Classification System (USCS) table.

3. From the result, it can be conclude that the bauxite deposit is in the right range of specific gravity and in the journal of basic properties of Gebeng bauxite state that specific gravity for bauxite is between 2.5 –3.0 (Muzamir Hasan, 2017).

5.2 Recommendation

For future recommendation for research:

1. Improving the result of physical properties by comparing the result with more samples.

2. For specific gravity, the weighing should be accurate and avoid the presence of entrapped air to have less error at the result.

3. The soil sample taken for testing have to be completely oven dried.

4. For the moisture content test, make sure the sample should be test immediately because it will affect the percentage of moisture content for the sample.

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APPENDIX A
SAMPLE APPENDIX 1

A.1 Raw data of moisture content at each site

Moisture content at Semambu :

TEST NUMBER	Unit	SM1	SM2	SM3	SM4	SM5
Container weight	Gm	13.84	23.18	24.59	22.97	24.06
Wet soil + container	Gm	48.65	72.58	76.38	75.83	78.59
Wet soil, W_w	Gm	34.81	49.40	51.79	52.86	54.53
Dry soil + container	Gm	39.65	60.89	64.07	62.25	64.53
Dry soil, W_d	Gm	25.81	37.71	39.48	39.28	40.47
Moisture loss, (W_w-W_d)	Gm	9.00	11.69	12.31	13.58	14.06
Moisture content, $(W_w-W_d) / W_d$	%	34.87	31.00	31.18	34.57	34.74
Range of moisture content	%	31.00 – 34.87				
AVERAGE MOISTURE CONTENT	%	33.27				

Moisture content at Bukit Goh :

TEST NUMBER	Unit	BG1	BG2	BG3	BG4	BG5
Container weight	Gm	30.49	23.54	22.69	23.94	23.64
Wet soil + container	Gm	86.04	81.46	74.92	83.22	79.18
Wet soil, W_w	Gm	55.55	57.92	52.23	59.28	55.54
Dry soil + container	Gm	75.02	72.81	63.18	72.79	71.50
Dry soil, W_d	Gm	44.53	49.27	40.49	48.85	47.86
Moisture loss, (W_w-W_d)	Gm	11.02	8.65	11.74	10.43	7.68
Moisture content, $(W_w-W_d) / W_d$	%	24.75	17.56	29.00	21.35	16.05
Range of moisture content	%	16.05 – 29.00				
AVERAGE MOISTURE CONTENT	%	21.74				

Moisture content at Indera Mahkota :

TEST NUMBER	Unit	IM1	IM2	IM3	IM4	IM5
Container weight	Gm	23.50	23.11	24.15	25.53	31.94
Wet soil + container	Gm	85.88	64.81	65.28	77.63	76.99
Wet soil, W_w	Gm	62.38	41.70	41.13	52.1	45.05
Dry soil + container	Gm	78.69	59.91	60.55	71.61	71.83
Dry soil, W_d	Gm	55.19	36.80	36.40	46.08	39.89
Moisture loss, (W_w-W_d)	Gm	7.19	4.9	4.73	6.02	5.16
Moisture content, $(W_w-W_d) / W_d$	%	13.03	13.32	12.99	13.06	12.94
Range of moisture comtent	%	12.94 – 13.32				
AVERAGE MOISTURE CONTENT	%	13.07				

APPENDIX B
SAMPLE APPENDIX 2

A.2 Raw data of particle size distribution at each site

Particle size distribution at Semambu :

Sieve size (mm)	Weight of sieve and retained (g)	Weight of sieve (g)	Weight retained (g)	Percentage Cumulative Passing (%)	Perfect Finer (%)
10.000	659.74	592.14	67.60	13.37	86.63
6.300	567.59	515.48	52.11	23.68	76.32
5.000	444.30	414.18	30.12	29.63	70.37
3.350	585.34	542.98	42.36	38.01	61.99
1.180	629.29	485.54	143.75	66.45	33.55
0.600	562.35	483.83	78.52	81.98	18.02
0.300	473.96	431.18	42.78	90.44	9.56
0.150	442.52	421.76	20.76	94.54	5.46
0.063	314.56	300.36	14.20	97.35	2.65
Pan	256.64	243.25	13.39	100	0
Total			505.59		

Particle size distribution at Bukit Goh :

Sieve size (mm)	Weight of sieve and retained (g)	Weight of sieve (g)	Weight retained (g)	Percentage Cumulative Passing (%)	Perfect Finer (%)
10.000	616.67	592.12	24.55	4.61	95.39
6.300	548.00	515.37	32.63	10.73	89.27
5.000	536.53	508.49	28.04	15.99	84.01
3.350	591.05	540.06	50.99	25.56	74.44
1.180	683.14	514.48	168.66	57.21	42.79
0.600	478.92	391.16	87.76	73.68	26.32
0.300	510.53	448.35	62.18	85.35	14.65
0.150	462.21	426.18	36.03	92.11	7.89
0.063	326.31	299.30	27.01	97.18	2.82
Pan	258.39	243.28	15.11	100	0
Total			532.96		

Particle size distribution at Indera Mahkota :

Sieve size (mm)	Weight of sieve and retained (g)	Weight of sieve (g)	Weight retained (g)	Percentage Cumulative Passing (%)	Perfect Finer (%)
10.000	611.89	592.09	19.80	3.78	96.22
6.300	449.81	409.87	39.94	11.4	88.6
5.000	542.45	508.46	33.99	17.88	82.12
3.350	605.37	540.01	65.36	30.35	69.65
1.180	673.71	514.26	159.45	60.76	39.24
0.600	459.78	390.92	68.86	73.89	26.11
0.300	503.49	448.21	55.28	84.43	15.57
0.150	463.77	426.14	37.63	91.61	8.39
0.063	326.45	298.97	27.48	96.85	3.15
Pan	259.80	243.30	16.50	100	0
Total			524.29		

APPENDIX C
SAMPLE APPENDIX 2

A.3 Raw data of atterberg limit at each site

Liquid limit at Semambu :

Test number	1		2		3	
Cone penetration (mm)	14.40	15.10	21.00	19.80	24.90	24.50
Average penetration (mm)	14.75		20.40		24.70	
Container number	A	B	C	D	E	F
Container weight (gm)	13.93	13.76	15.63	14.24	14.42	14.91
Wet soil + container (gm)	20.46	21.96	23.43	22.06	22.76	23.81
Wet soil, W_w (gm)	6.53	8.20	7.80	7.82	8.34	8.90
Dry soil + container (gm)	18.15	19.04	20.68	19.29	19.46	20.30
Dry soil, W_d (gm)	4.22	5.28	5.05	5.05	5.04	5.39
Moisture loss, (W_w-W_d) (gm)	2.31	2.92	2.75	2.77	3.30	3.51
Moisture content, (W_w-W_d) / W_d (%)	54.74	55.30	54.46	54.85	65.48	65.12
Average moisture content (%)	55.02		54.66		65.30	

Plastic limit at Semambu :

Container Number	A	B
Container weight (gm)	15.09	15.80
Wet soil + container (gm)	28.28	26.68
Wet soil, W_w (gm)	13.19	10.88
Dry soil + container (gm)	24.09	23.19
Dry soil, W_d (gm)	9.00	7.39
Moisture loss, (W_w-W_d) (gm)	4.19	3.49
Moisture content, (W_w-W_d) / W_d (%)	46.56	47.23
Average moisture content (%)	46.90	

Linear shrinkage at Semambu :

SAMPLE DESCRIPTION		
Initial length, L_O	mm	146.00
Oven-dried Length, L_D	mm	135.50
Linear shrinkage, $\left(1-\frac{L_D}{L_O}\right)x\ 100$	%	7.19

Liquid limit at Bukit Goh :

Test number	1		2		3	
Cone penetration (mm)	15.80	14.30	18.20	18.80	24.80	25.70
Average penetration (mm)	15.05		18.50		25.25	
Container number	A	B	C	D	E	F
Container weight (gm)	15.90	15.12	13.98	13.81	14.19	14.89
Wet soil + container (gm)	25.55	26.20	25.82	25.37	24.87	26.11
Wet soil, W_w (gm)	9.65	11.08	11.84	11.56	10.68	11.22
Dry soil + container (gm)	22.57	22.85	22.06	21.73	21.50	22.60
Dry soil, W_d (gm)	6.67	7.73	8.08	7.92	7.31	7.71
Moisture loss, (W_w-W_d) (gm)	2.98	3.35	3.76	3.64	3.37	3.51
Moisture content, (W_w-W_d) / W_d (%)	44.68	43.34	46.53	45.96	46.10	45.53
Average moisture content (%)	44.01		46.25		45.82	

Plastic limit at Bukit Goh :

Container Number	A	B
Container weight (gm)	14.94	14.61
Wet soil + container (gm)	33.77	33.48
Wet soil, W_w (gm)	18.83	18.87
Dry soil + container (gm)	28.57	28.34
Dry soil, W_d (gm)	13.63	13.73
Moisture loss, (W_w-W_d) (gm)	5.20	5.14
Moisture content, (W_w-W_d) / W_d (%)	38.15	37.44
AVERAGE MOISTURE CONTENT (%)	37.80	

Linear shrinkage at Bukit Goh :

SAMPLE DESCRIPTION		
Initial length, L_O	mm	146.00
Oven-dried Length, L_D	mm	134.60
Linear shrinkage, $\left(1 - \frac{L_D}{L_O}\right) x\ 100$	%	7.81

Liquid limit at Indera Mahkota :

TEST NUMBER	1		2		3	
Cone penetration (mm)	14.30	16.00	20.40	21.60	26.00	24.50
Average penetration (mm)	15.15		21		25.25	
CONTAINER NUMBER	A	B	C	D	E	F
Container weight (gm)	14.40	15.07	14.84	15.17	15.12	14.69
Wet soil + container (gm)	25.97	27.84	27.82	28.04	26.37	25.74
Wet soil, W_w (gm)	11.57	12.77	12.98	12.87	11.25	11.05
Dry soil + container (gm)	23.28	24.84	24.71	24.94	23.67	23.05
Dry soil, W_d (gm)	8.88	9.77	9.87	9.77	8.55	8.36
Moisture loss, (W_w-W_d) (gm)	2.69	3.00	3.11	3.10	2.70	2.69
Moisture content, (W_w-W_d) / W_d (%)	30.29	30.70	31.51	31.73	31.58	32.18
AVERAGE MOISTURE CONTENT (%)	30.50		31.62		31.88	

Plastic limit at Indera Mahkota :

Container Number	A	B
Container weight (gm)	14.42	14.66
Wet soil + container (gm)	34.05	31.45
Wet soil, W_w (gm)	19.63	16.79
Dry soil + container (gm)	30.06	28.02
Dry soil, W_d (gm)	15.64	13.36
Moisture loss, (W_w-W_d) (gm)	3.99	3.43
Moisture content, (W_w-W_d) / W_d (%)	25.51	25.67
AVERAGE MOISTURE CONTENT (%)	25.59	

Linear shrinkage at Indera Mahkota :

SAMPLE DESCRIPTION		
Initial length, L_O	mm	146.00
Oven-dried Length, L_D	mm	134.20
Linear shrinkage, $\left(1-\frac{L_D}{L_O}\right)x\ 100$	%	8.08

APPENDIX D
SAMPLE APPENDIX 1

A.1 Raw data of specific gravity at each site

Specific gravity at Semambu :

Semambu 1

Test number	**Unit**	**1**	**2**	**3**
Mass of bottle + stopper, m_1	g	33.72	33.61	34.62
Mass of bottle + stopper + dry soil, m_2	g	45.77	45.90	46.91
Mass of bottle + stopper + soil + water, m_3	g	140.94	140.83	142.05
Mass of bottle + stopper +water, m_4	g	133.61	133.21	134.34
Mass of dry soil, $(m_2 - m_1)$	g	12.05	12.29	12.29
Mass of water in full bottle, $(m_4 - m_1)$	g	99.89	99.60	99.72
Mass of water used, $(m_3 - m_2)$	g	95.17	94.93	95.14
Particle density, ρ_s	mg/m^3	2.55	2.63	2.68
AVERAGE PARTICLE DENSITY, $\boldsymbol{\rho_s}$	mg/m^3	2.62		

Semambu 2

Test number	**Unit**	**1**	**2**	**3**
Mass of bottle + stopper, m_1	g	31.04	30.67	31.51
Mass of bottle + stopper + dry soil, m_2	g	43.25	42.70	43.63
Mass of bottle + stopper + soil + water, m_3	g	138.96	139.33	139.37
Mass of bottle + stopper +water, m_4	g	130.87	131.38	131.48
Mass of dry soil, $(m_2 - m_1)$	g	12.21	12.03	12.12
Mass of water in full bottle, $(m_4 - m_1)$	g	99.83	100.71	99.97
Mass of water used, $(m_3 - m_2)$	g	95.71	96.63	95.74
Particle density, ρ_s	mg/m^3	2.96	2.95	2.87
AVERAGE PARTICLE DENSITY, $\boldsymbol{\rho_s}$	mg/m^3	2.93		

Semambu 3

Test number	Unit	1	2	3
Mass of bottle + stopper, m_1	g	31.65	31.00	31.48
Mass of bottle + stopper + dry soil, m_2	g	43.94	43.03	43.63
Mass of bottle + stopper + soil + water, m_3	g	139.08	139.66	139.37
Mass of bottle + stopper +water, m_4	g	131.37	131.71	131.48
Mass of dry soil, $(m_2 – m_1)$	g	12.29	12.03	12.15
Mass of water in full bottle, $(m_4 – m_1)$	g	99.72	100.71	100.00
Mass of water used, $(m_3 – m_2)$	g	95.14	96.63	95.74
Particle density, ρ_s	mg/m^3	2.68	2.95	2.85
AVERAGE PARTICLE DENSITY, $\boldsymbol{\rho_s}$	mg/m^3	2.82		

Specific gravity at Bukit Goh :

Bukit Goh 1

Test number	Unit	1	2	3
Mass of bottle + stopper, m_1	g	32.65	32.25	36.75
Mass of bottle + stopper + dry soil, m_2	g	44.63	44.22	49.01
Mass of bottle + stopper + soil + water, m_3	g	140.39	139.76	144.32
Mass of bottle + stopper +water, m_4	g	132.41	131.72	136.18
Mass of dry soil, $(m_2 – m_1)$	g	11.98	11.97	12.26
Mass of water in full bottle, $(m_4 – m_1)$	g	99.76	99.47	99.43
Mass of water used, $(m_3 – m_2)$	g	95.76	95.54	95.31
Particle density, ρ_s	mg/m^3	3.00	3.05	2.98
AVERAGE PARTICLE DENSITY, $\boldsymbol{\rho_s}$	mg/m^3	3.01		

Bukit Goh 2

Test number	Unit	1	2	3
Mass of bottle + stopper, m_1	g	33.65	32.55	35.93
Mass of bottle + stopper + dry soil, m_2	g	45.60	44.98	48.01
Mass of bottle + stopper + soil + water, m_3	g	141.40	140.67	143.33
Mass of bottle + stopper +water, m_4	g	133.20	132.68	136.09
Mass of dry soil, $(m_2 – m_1)$	g	11.95	12.43	12.08
Mass of water in full bottle, $(m_4 – m_1)$	g	99.55	100.13	100.16
Mass of water used, $(m_3 – m_2)$	g	95.80	95.69	95.32
Particle density, ρ_s	mg/m^3	3.19	2.80	2.50
AVERAGE PARTICLE DENSITY, $\boldsymbol{\rho_s}$	mg/m^3	2.83		

Bukit Goh 3

Test number	Unit	1	2	3
Mass of bottle + stopper, m_1	g	32.37	32.00	32.84
Mass of bottle + stopper + dry soil, m_2	g	44.58	44.03	44.94
Mass of bottle + stopper + soil + water, m_3	g	140.29	140.66	141.79
Mass of bottle + stopper +water, m_4	g	132.20	132.71	133.78
Mass of dry soil, $(m_2 – m_1)$	g	12.21	12.03	12.10
Mass of water in full bottle, $(m_4 – m_1)$	g	99.83	100.71	100.94
Mass of water used, $(m_3 – m_2)$	g	95.71	96.63	96.85
Particle density, ρ_s	mg/m^3	2.96	2.95	2.96
AVERAGE PARTICLE DENSITY, $\boldsymbol{\rho_s}$	mg/m^3	2.96		

Indera Mahkota 1

Test number	Unit	1	2	3
Mass of bottle + stopper, m_1	g	36.70	30.38	31.94
Mass of bottle + stopper + dry soil, m_2	g	48.80	42.47	43.88
Mass of bottle + stopper + soil + water, m_3	g	143.57	138.31	140.24
Mass of bottle + stopper +water, m_4	g	136.14	130.98	132.96
Mass of dry soil, ($m_2 – m_1$)	g	12.10	12.09	11.94
Mass of water in full bottle, ($m_4 – m_1$)	g	99.44	100.60	101.02
Mass of water used, ($m_3 – m_2$)	g	94.77	95.84	96.36
Particle density, ρ_s	mg/m^3	2.59	2.54	2.56
AVERAGE PARTICLE DENSITY, $\boldsymbol{\rho_s}$	mg/m^3	2.56		

Indera Mahkota 2

Test number	Unit	1	2	3
Mass of bottle + stopper, m_1	g	31.75	31.64	32.65
Mass of bottle + stopper + dry soil, m_2	g	43.80	43.93	44.94
Mass of bottle + stopper + soil + water, m_3	g	139.01	138.86	140.08
Mass of bottle + stopper +water, m_4	g	131.64	131.24	132.37
Mass of dry soil, ($m_2 – m_1$)	g	12.05	12.29	12.29
Mass of water in full bottle, ($m_4 – m_1$)	g	99.89	99.60	99.72
Mass of water used, ($m_3 – m_2$)	g	95.21	94.93	95.14
Particle density, ρ_s	mg/m^3	2.57	2.63	2.68
AVERAGE PARTICLE DENSITY, $\boldsymbol{\rho_s}$	mg/m^3	2.63		

Indera Mahkota 3

Test number	**Unit**	**1**	**2**	**3**
Mass of bottle + stopper, m_1	g	32.80	32.69	33.70
Mass of bottle + stopper + dry soil, m_2	g	44.85	44.97	45.99
Mass of bottle + stopper + soil + water, m_3	g	140.06	139.91	141.13
Mass of bottle + stopper +water, m_4	g	132.69	132.29	133.42
Mass of dry soil, $(m_2 – m_1)$	g	12.05	12.28	12.29
Mass of water in full bottle, $(m_4 – m_1)$	g	99.89	99.60	99.72
Mass of water used, $(m_3 – m_2)$	g	95.21	94.94	95.14
Particle density, ρ_s	mg/m^3	2.57	2.64	2.68
AVERAGE PARTICLE DENSITY, $\boldsymbol{\rho_s}$	mg/m^3	2.63		